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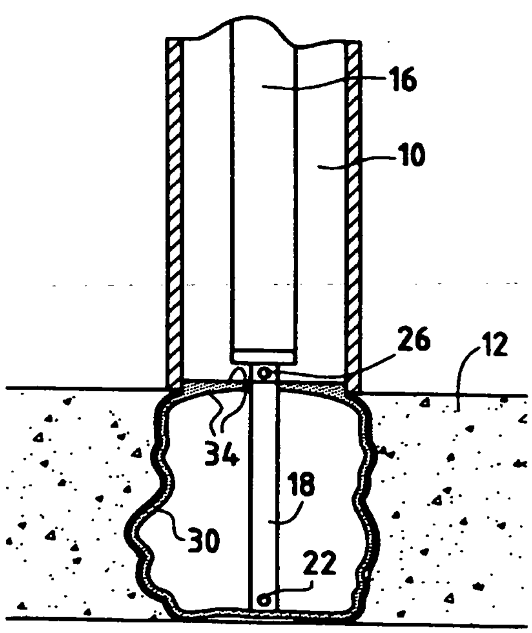

(57) Abstract: Apparatus for stabilising a borehole includes a delivery pipe (16) for delivering a treatment fluid to a zone of the borehole to be stabilised, the pipe having an opening (22) such that a treatment fluid can flow from the pipe into the zone; and a flexible, expandable sleeve (30) secured on the outside of the pipe (16) around the opening (22) such that fluid flowing from the pipe through the opening flows into the sleeve (30), the sleeve being formed from a permeable material that allows at least a portion of the fluid to pass therethrough into contact with the zone of the borehole.

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METHOD AND APPARATUS FOR BOREHOLE STABILISATION

The present invention relates to the stabilisation or treatment of boreholes, in particular oil, gas, water or geothermal wells or the like. The methods and apparatus according to the invention utilise a sleeve around a delivery tube to confine a treatment fluid in a zone to be stabilised or isolated.

In this application, the terms "stabilisation" is used to include isolation, treatment and stabilisation of the formation or of the annulus inside the borehole. Stabilisation of boreholes can take several forms. In zonal isolation, the stabilisation takes the form of a seal placed over a zone of the borehole to prevent fluids flowing into or out of the zone. This is typically achieved by placing a tubular casing inside the borehole and filling the annulus between the casing and the borehole wall with impermeable cement. Often the zone to be isolated is of relatively limited axial extent, but the only way to ensure that the cement sheath extends over the zone of interest is to cement a relatively long part of the well from below the zone to above it. It is often difficult to ensure that small volumes of cement are set in the proper place. Other forms of stabilisation or treatment include squeeze cementing for consolidation, gravel packing and other such treatments.

Similar processes can also be used where the borehole passes through weak or unconsolidated formations that can be easily eroded during drilling or production from the well. When drilling encounters highly fractured formations, or caverns, the drilling fluid being used to drill the well is often lost into the formation. This situation is known as lost circulation and can lead to significant increase in cost of the drilling operation due to the loss of the drilling fluid and the difficulty in controlling the drilling process. Sometimes, it is possible to remedy lost circulation by adding materials to the drilling fluid which plug the formation around the borehole and reduce or prevent further fluid loss. However, in many situations, this is not possible. In such cases, a current approach is to set a cement plug in the borehole and then drill though the cement plug, the remaining cement acting as an impermeable barrier to further fluid loss in the zone in question. Unfortunately, it is possible that the cement can also be lost to the formation because of the large size of the fractures and the hydrostatic pressure in the well. To address this problem, it has been proposed to add

plugging materials such as fibres to cement to provide some form of structure to the cement plug while it sets. US 6,102,121 describes the use of such materials in lost circulation situations.

There have been previous proposals that attempt to address this problem by using a downhole sleeve to confine the cement to a specific zone of the well. Examples of this can be seen in US 2,796,134 and US 3,032,115. In both cases, a drillable delivery pipe is placed in the well with openings to allow cement to pass into the annulus. A sleeve is located around the openings and cement is pumped through the pipe into the sleeve to inflate it and seal against the formation. Suitable materials proposed for these uses are plastic or rubber. Once the cement has set, the delivery pipe is disconnected above the sleeve and the portion in the sleeve drilled out leaving the cement sheath in place. In these schemes, an impermeable sleeve is used to ensure that the cement is confined to the area of interest. None of these proposals demonstrate particularly effective cement properties in the region of particular interest: the borehole wall.

None of these previous approaches using sleeves in stabilisation is known to be particularly effective. A similar process for a somewhat different use can be seen in previously proposed external casing packers (ECP's). ECP's are rubber sleeves that are placed around casings or liners that are not otherwise cemented into the borehole. One typical case of this is found in the use of slotted liners, where it is not possible to create the cement sheath because the slots in the liner allow fluid communication between the annulus and the inside of the liner over substantially all of its surface. ECP's are placed around the liners at various positions in the well and can be inflated by pumping cement into them so as to cause them to seal against the formation. This blocks the annulus and forces fluid flow to pass inside the liner, at which point other well interventions can take place to control the flow or production. ECP's are also not particularly effective, either because they are often damaged during placement in the well, or because they fail to inflate and seal properly.

It is an object of the present invention to provide a sleeve-based stabilisation technique which obviates or mitigates these problems.

A first aspect of the invention provides apparatus for stabilising a borehole, comprising: a delivery pipe for delivering a treatment fluid to a zone of the borehole to be stabilised, the pipe having an opening such that a treatment fluid can flow from the pipe into the zone; and a flexible, expandable sleeve secured on the outside of the pipe around the opening such that fluid flowing from the pipe through the opening flows into the sleeve; characterised in that the sleeve is formed from a permeable material.

The permeable material can allow at least a portion of the fluid to pass therethrough into contact with the zone of the borehole.

Where the treatment fluid is a mixture of solid and liquid components, the portion of the treatment fluid passing through the sleeve can be a predominantly liquid component of the fluid so as to form an enriched layer of solids near the sleeve. Such solids can include fibres or other materials included in the fluid to form a filter cake inside the sleeve.

The delivery pipe preferably comprises a tube formed from aluminium or fibre reinforced plastics material or other such material. The delivery pipe typically has a diameter that is smaller than the diameter of the borehole in the zone to be stabilised and smaller than the diameter of any casing above this zone. The stinger can connected to the remaining part of the delivery pipe by means of a releasable connector which is operable such that the remaining part of the delivery pipe can be disconnected from the stinger and withdrawn from the borehole after the treatment fluid has been placed.

Openings in the delivery pipe are preferably in the sidewall of the delivery pipe, the sleeve being connected to the outside of the pipe above and below the openings.

The sleeve preferably has a mesh-like structure that can be formed, for example, by weaving or knitting fibres. Suitable fibre materials are steel, glass fibre, carbon fibre, Kevlar and other such materials, and combinations thereof. The mesh is typically sufficiently loose to allow expansion of the sleeve when filled with treatment fluid without losing its ability to retain at least part of the fluid. This expansion can be up to

50% of the unexpanded diameter of the sleeve, although even greater expansion can be achieved according to the design of the mesh and the degree of filtering required. The unexpanded diameter of the sleeve can typically be 3 – 4 times the diameter of the delivery pipe.

A second aspect of the invention provides a method of stabilising a borehole, comprising: positioning a pipe in the borehole to deliver a treatment fluid to a zone to be stabilised, the pipe having an opening such that the fluid can flow from the pipe into the zone; securing a sleeve on the outside of the pipe around the opening such that fluid flowing from the pipe through the opening flows into the sleeve; and flowing the treatment fluid through the pipe opening into the sleeve; characterised in that the sleeve is formed from a permeable material, the method further comprising flowing the treatment fluid into the sleeve such that at least that at least a portion of the fluid passes therethrough into contact with the zone of the borehole.

Following the step of flowing the treatment fluid into the sleeve, it is possible to leave at least the portion of the delivery pipe in the zone to be stabilised by disconnecting the portion of the delivery pipe extending from the zone to the surface from the portion remaining in the zone.

Typically, treatment fluid is placed in the sleeve so as to expand the sleeve until it fills substantially all of the annulus in the zone to be stabilised. When the annulus is very large or irregular, it may be desirable to fill the sleeve until a predetermined pressure of fluid is reached.

One suitable treatment fluid is preferably a cement slurry comprising liquid and solid components. The effect of the sleeve is to concentrate the solid component of the slurry near the borehole wall leading to improved physical properties in this region. To avoid excessive loss of solids through the sleeve, it is preferred to include suitable plugging materials, such as fibres, in the slurry. The plugging materials chosen, typically fibres, are selected according to the mesh size of the sleeve.

It is particularly preferred to use a cement slurry with an optimised particle size distribution of solid materials to obtain a high packing volume fraction.

Other treatment fluids may also be useful in the present invention, for example dispersed gels or polymers that can concentrate at the borehole wall, or materials for sand control, gravel packs or the like.

Examples of the present invention will now be described with reference to the accompanying drawings, in which:
Figure 1 shows one embodiment of the invention;
Figure 2 shows the embodiment of Figure 1 in use;
Figure 3 shows a later phase of the use of the embodiment of Figure 1;and
Figure 4 shows a borehole that has been stabilised after under-reaming.

Figure 1 shows a borehole 10 which has been drilled into a highly fractured and permeable formation 12 that has a relatively low formation pressure. Consequently, drilling fluid is lost to the formation because the hydrostatic pressure of the fluid at this depth exceeds the formation pressure and the highly fractured nature of the formation 12 means that it is not possible to build a mud cake on the wall of the borehole to prevent fluid loss. Drilling is stopped and the drill string withdrawn from the borehole. An apparatus 14 according to one embodiment of the invention is connected to drill pipe 16 as shown in Figure 1 and lowered into the borehole to the level of the zone to be stabilised 12. The apparatus 14 comprises a drillable stinger 18 formed from an aluminium tube (other drillable materials such as fibre reinforced composites can also be used) which is connected to the lower end of the drill pipe 16 by means of a pressure operated disconnect 20. The length and diameter of the stinger will be selected according to operational requirements, e.g. length of zone to be stabilised, hole diameter, thickness of cement required. The disconnect is operable by pumping a dart or ball down the inside of the drill pipe 16 to sit in a seat and cause sufficient pressure to build to break shear pins (not shown) in the conventional manner. Ports 22 are provided in the stinger 18 near its lower end 24 which is otherwise closed. Pressure relief ports 26 are provided near the upper end 28 of the stinger 18.

A permeable sleeve 30 is secured around the outside of the stinger below the ports 22 and pressure relief ports 26 so as to extend along the outer surface of the stinger 18 in

the stabilisation zone 12. The sleeve 30 can be formed from a woven carbon fibre or Kevlar material such as the preformed tubular materials available from A&P Technology under reference RA3827SPAR and RF1345 (it will be appreciated that other materials can also be used). For a nominal 8 inch borehole, an 8 inch sleeve (unexpanded) is proposed. The sleeve 30 is attached to the stinger 18 by means of clamps 32 that are made from a drillable material such as epoxy resin materials, aluminium, etc..

In use (see Figure 2), cement slurry is pumped down the drill pipe 16 from mixing equipment at the surface (not shown) into the stinger 18 and from there into the sleeve 30 through the ports 22. The cement fills the sleeve 30 and causes it to expand until it comes into contact with the formation 12. A typical expansion might be up to 50% of the starting diameter of the sleeve 30 in its unexpanded form although the exact expansion might be greater or less than this according to requirements. Because of the permeable nature of the sleeve 30, part of the slurry passes through the sleeve and contacts the formation 12. As the larger solid particles are retained by the sleeve mesh, this is in effect a type of squeeze cementing operation, the filtered slurry permeating the formation around the borehole. Also, when the sleeve is filled, cement will pass through the upper surface 32 of the sleeve 30 to form a cement layer 34 over the sleeve 30 and around the stinger 18 (see Figure 2). The cement slurry is pumped until the pressure in the sleeve reaches a predetermined limit (see below) at which point pumping is stopped or is continued through the relief ports 26 in which case, a ball or dart can be pumped to operate the disconnect 20 and the drill pipe 16 withdrawn from the borehole 10.

Once the cement has set, the drill pipe 16 is reintroduced with a drill bit 40 attached and drilling recommences, drilling through the stinger 18 and cement inside the sleeve 30 to leave the remaining part of the sleeve 30' and a sheath of cement 36 around the borehole 10 in the zone 12 (see Figure 3). This acts as an impermeable barrier between the borehole 10 and the formation 12 that can sustain the hydrostatic pressure of the drilling fluid and so avoid the fluid loss problem. The presence of the cement cap on top of the sleeve and stinger assists in effective resumption of drilling and removal of the stinger.

The design of the cement slurry used in this operation will be determined according to the particular requirements of the cement sheath. It is preferred that the cement utilises an optimised particle size distribution for the solid components of the slurry such as is described in EP 0 621 247.

Where a low density cement slurry is required, the approach proposed in WO 01/09056 is preferred. An example of such a base low density slurry is given in Table 1 below:

Table 1

BVOB = by volume of total solids in slurry

gal/sk = gallons per sack of cement

ppg = pounds per gallon

porosity % = (volume of water/volume of slurry) * 100

Class G Cement (20 – 25 micron)	35% BVOB
Crystalline Silica (1 – 10 micron)	10% BVOB
Aluminium Silicate Microspheres SG 0.65 – 0.85 (100 – 400 micron)	55% BVOB
Polypropylene Glycol antifoam agent	0.025 gal/sk
Water	5.029 gal/sk
Density	12.13 ppg
Porosity	43%

A suitable base higher density slurry is given in Table 2 below (same abbreviations as Table 1):

Table 2

Class G Cement (20 – 25 micron)	40% BVOB
Crystalline Silica (1 – 10 micron)	10% BVOB
Iron Oxide weighting agent , SG 4.8 – 6.0 (100 – 600 micron)	10% BVOB
Silicon Dioxide weighting agent, SG 2.5 – 2.8 (100 – 600 micron)	40% BVOB

Polymeric Aliphatic Amide fluid loss control additive	0.3% BVOB
Polypropylene Glycol antifoam agent	0.025 gal/sk
Water	2.625 gal/sk
Density	18.7 ppg
Porosity	40.5%

Fibre material is mixed with the base slurry to provide structure to the mass. Such fibres can be metallic (see, for example, WO 99/58467) or polymeric (see, for example, PCT/EP02/07899). Two suitable fibre materials and a proposed level of use in the cement slurries are given in Table 3 below:

Table 3

Fibre Material	Concentration
Novoloid polymer fibres (18 – 22 mm)	3 g/l of slurry
Amorphous cast metal fibres (5 – 10 mm)	100 g/l of slurry

The strength of the sleeve material and the cement are important parameters in designing an operation in accordance with the invention. One of the most severe conditions lies in the case of the absence of support from the formation, for example when plugging caverns or highly unconsolidated formations. The strength requirement can be calculated using the following equations:

$$\sigma_t = K\Delta P_a \qquad (1)$$

With ΔP_a designating the differential pressure in the borehole, σ_t the tangential stress in a solid annulus at the wall of the borehole and K a stress intensity factor which, in the case of a solid unsupported annulus, is equal to

$$K = \left(\frac{r_b^2 + r_a^2}{r_b^2 - r_a^2}\right) \qquad (2)$$

In which r_b and r_a represent respectively the outside diameter and the inside diameter of the solid annulus.

Using these equations, it is possible to estimate the strength requirements for the mesh and the cement.

If it is assumed that it is wished to consolidate a 10 foot section (304.8 cm) composed of broad cavities, the following procedure can be followed. The bottom of the area is situated at 3000 feet (914 m) with a pressure gradient of 0.3 psi/foot (total losses) (6.8 x 10^3 N/m^3), that is to say the pressure at the bottom of the section is 3000 x 0.3 = 900 psi (6.2 x 10^6 N/m^2). A cement slurry has, for example, a density of 0.8 psi/foot (1.8 x 10^4 N/m^3). In order to ensure good coverage of the zone, a height of cement of 100 feet (30.48 m) might be appropriate. At 2900 feet (884 m), the hydrostatic pressure at the top of the column of cement is approximately 900 - (100 x 0.44) = 850 psi (5.9 x 10^6 N/m^2). For simplicity of calculation, the borehole fluid is taken to be water and with a water level at approximately 950 feet (291.39 m), and a total loss situation is assumed. At the bottom of the section, the slurry will impose a pressure on the mesh of 850 psi + (0.8 x 100) psi = 936 psi (6.4 x 10^6 N/m^2). The differential pressure through the mesh is therefore 36 psi (0.25 x 10^6 N/m^2). The cement, in the hardened state, must support in that part of the borehole a pressure of 1320 psi (9.1 x 10^6 N/m^2) if the borehole fluid is water (0.44 psi/foot (9.9 x 10^3 N/m^3) with a column height of 3000 feet (914 m)). The differential pressure for the cement is therefore 1320 - 900 = 420 psi (2.9 x 10^6 N/m^2). If the borehole fluid is heavier than water, the differential pressure increases accordingly.

The strength of the mesh forming the sleeve is an important parameter. For example, assuming an 8 x 8 hard drawn, high carbon content steel cable mesh with a nominal yield strength of 300,000 psi (2068.4 x 10^6 N/m^2), having a mesh diameter of 0.71 mm, an opening of 2.47 mm (a 5 mm steel fibre is not capable of passing through such an opening), the average tangential force over the volume occupied by the mesh is approximately 250 times the differential pressure, that is to say approximately 9000 psi (62 x 10^6 N/m^2) (using equation 2 above) and an outside diameter of the mesh of 355.6 mm. The tensile stress on the cables is approximately 9000 x (2.47 + 0.71)70.71 = 40,000 psi (275.8 x 10^6 N/m^2).

In this calculation the average stress applied to the volume of the mesh is redistributed over the volume of the fibres. This simplified approach suggests that the mesh selected is capable of supporting and withstanding approximately 7 times the differential pressure of 36 psi (0.25 x 10^6 N/m^2) before beginning to yield. The actual

tensile strength of the mesh itself will depend in fact on many other parameters such as the orientation of the steel cables, the material used, etc.. For example, a carbon fibre mesh has a tensile strength of approximately 640,000 psi (4414×10^6 N/m^2). It appears at the present time that the mesh can provide appreciable support for the cement. It is also possible to envisage the use of a cement of lower density.

Similar calculations are made for cement. Assuming that the cement is not supported by the formation because of the presence of cavities, and the support afforded by the mesh is ignored, it is possible to apply the following reasoning: for a mass of cement having an outside diameter (equal to the diameter of the mesh) twice that of its inside diameter, the tangential tensile stress in the cement at the wall of the borehole is 5/3 times the differential pressure, according to equation 2, that is to say 700 psi (4.8×10^6 N/m^2). This means that it is necessary to use a reinforced cement with a tensile strength of at least 700 psi (4.8×10^6 N/m^2), typically comprising metallic fibres. Well cements with a tensile strength of 1000 psi (6.89×10^6 N/m^2) are known.

In order to increase the reliability of the system, the mesh must be sufficiently strong to support the cement. The use of a cement with lower density or application to a shorter length of the stabilisation zone will reduce the strength requirement of the mesh during the placing of the cement. The outside diameter can also be increased in order to reduce the tensile stress on the cement sheath.

The sleeve is preferably highly flexible in order to adapt to the dimensions and shape of the borehole whilst retaining good mechanical strength. Therefore carbon fibre, Kevlar or steel can be used. An appropriate material has a high tensile strength under downhole conditions and is not excessively degraded by fluids present in the well, at least until a permanent casing is installed. The structure of the mesh affords the required flexibility. However, it may also be necessary to be able to drill through the sleeve (see the lost circulation example given above), the cement providing an impermeable layer, which makes it possible to drill the borehole without loss of circulation and increases the strength of the structure.

It is also possible to increase the diameter of the zone to be reinforced by means of appropriate tools ("under reamers") in order to increase the cemented volume. An

example of this is shown in Figure 4 in which the diameter of the borehole 11 in the zone to be stabilised 12 is enlarged relative to the portion 10 above. This allows a thicker cement layer 36' to be formed without the need to reduce the borehole diameter when drilling resumes.

Variations in the apparatus and method described above are possible within the scope of the invention. For example, the method can be used to provide zonal isolation over a limited vertical extent. If, during drilling, a zone of higher pressure, or significant water or gas flow is encountered, which can disrupt the drilling process. it may be possible to set a cement sheath following under reaming (see Figure 4 above) across the zone in question and continue to drill, without the need to set intermediate casing with the consequent cost and reduction in diameter of the borehole. In such a case, a strong, tough reinforced cement might be used to withstand the high stresses of drilling, such as is disclosed in WO 99/58467.

It is also possible to avoid damage to the sleeve when the apparatus is being lowered into the well by using centralisers above and below the sleeve to prevent contact with the borehole wall. Another approach is to use a cover over the sleeve which is removed when the sleeve is to be expanded.

While the invention has been described above in relation to a lost circulation problem, it will be appreciated that invention is not limited to such use. The invention allows control of the axial extent of the application of the treatment fluid and control of the permeability of the treatment. In the case of cementing, the object is typically to form a low permeability layer over a zone. The invention can also be used to set a gravel pack, a relatively high permeability treatment. In this latter case, the axial extent of the sleeve might be relatively large compared to that used in a lost circulation problem.

The invention may also be used in place of a conventional ECP. In this case, the sleeve is provided on the outside of casing rather than drill pipe or coiled tubing. The casing might be slotted liner.

CLAIMS

1 Apparatus for stabilising a borehole, comprising:

- a delivery pipe for delivering a treatment fluid to a zone of the borehole to be stabilised, the pipe having an opening such that a treament fluid can flow from the pipe into the zone; and
- a flexible, expandable sleeve secured on the outside of the pipe around the opening such that fluid flowing from the pipe through the opening flows into the sleeve;

characterised in that the sleeve is formed from a permeable material.

2 Apparatus as claimed in claim 1, wherein the treatment fluid comprises a solid component and a liquid component, the portion of the treatment fluid passing through the sleeve being part of the liquid component of the fluid so as to form an enriched layer of solids near the sleeve.

3 Apparatus as claimed in claim 1 or 2, wherein the delivery pipe comprises a stinger that is left in the borehole after the treatment fluid has been placed.

4 Apparatus as claimed in claim 1, 2 or 3, wherein the delivery pipe comprises a tube formed from aluminium or fibre reinforced plastics material or other such material.

5 Apparatus as claimed in claim 3 or 4, wherein the delivery pipe has a diameter that is smaller than the diameter of the borehole in the zone to be stabilised and smaller than the diameter of any casing above this zone.

6 Apparatus as claimed in claim 3, wherein the stinger is connected to a remaining part of the delivery pipe by means of a releasable connector which is operable such that the remaining part of the delivery pipe can be disconnected from the stinger and withdrawn from the borehole after the treatment fluid has been placed.

7 Apparatus as claimed in any preceding claim, wherein the openings in the delivery pipe are in the sidewall of the delivery pipe, the sleeve being connected to the outside of the pipe above and below the openings.

8 Apparatus as claimed in any preceding claim, wherein the sleeve has a mesh-like structure.

9 Apparatus as claimed in claim 8, wherein the sleeve is formed from steel, glass fibre, carbon fibre, Kevlar and other such materials, and combinations thereof.

10 Apparatus as claimed in claim 8 or 9, wherein the mesh is sufficiently loose to allow expansion of the sleeve when filled with treatment fluid.

11 Apparatus as claimed in claim 10, wherein the expansion is up to 50% of the unexpanded diameter of the sleeve.

12 Apparatus as claimed in claim 10 or 11, wherein the unexpanded diameter of the sleeve is 3 – 4 times the diameter of the delivery pipe.

13 A method of stabilising a borehole, comprising:

- positioning a pipe in the borehole to deliver a treatment fluid to a zone to be stabilised, the pipe having an opening such that the fluid can flow from the pipe into the zone;
- securing a sleeve on the outside of the pipe around the opening such that fluid flowing from the pipe through the opening flows into the sleeve; and
- flowing the treatment fluid through the pipe opening into the sleeve;

characterised in that the sleeve is formed from a permeable material, the method further comprising flowing the treatment fluid into the sleeve such that at least that at least a portion of the fluid passes therethrough into contact with the zone of the borehole..

14 A method as claimed in claim 13, wherein the treatment fluid comprises solid and liquid components, the method comprising forming a solids enriched layer near the sleeve by causing a liquid component of the fluid to pass through the sleeve.

15 A method as claimed in claim 13 or 14, wherein at least the portion of the delivery pipe is left in the zone to be stabilised following the step of flowing the treatment fluid into the sleeve.

16 A method as claimed in any of claims 13 – 15, comprising placing treatment fluid in the sleeve so as to expand the sleeve until it fills substantially all of the annulus in the zone to be stabilised.

17 A method as claimed in any of claims 13 – 16, comprising placing treatment fluid in the sleeve so as to expand the sleeve until a predetermined pressure of fluid is reached.

18 A method as claimed in any of claims 13 – 17, wherein the treatment fluid is a cement slurry comprising liquid and solid components.

19 A method as claimed in claim 18, wherein the cement slurry includes fibres.

20 A method as claimed in any of claims 13 – 17 when used to install a gravel pack in the borehole.

21 A method as claimed in any of claims 13 – 19, when used to provide external casing packers in a borehole.

FIG.1

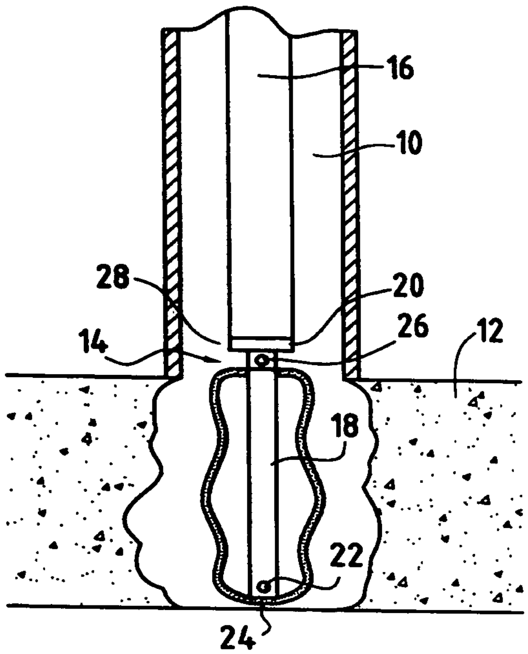


FIG.2

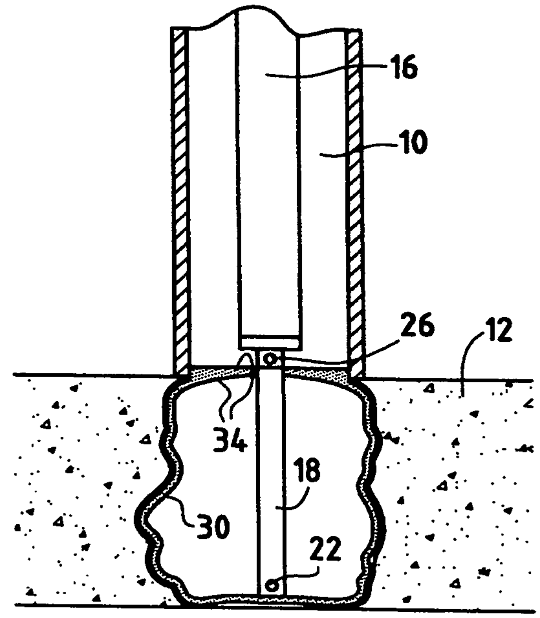


FIG.3

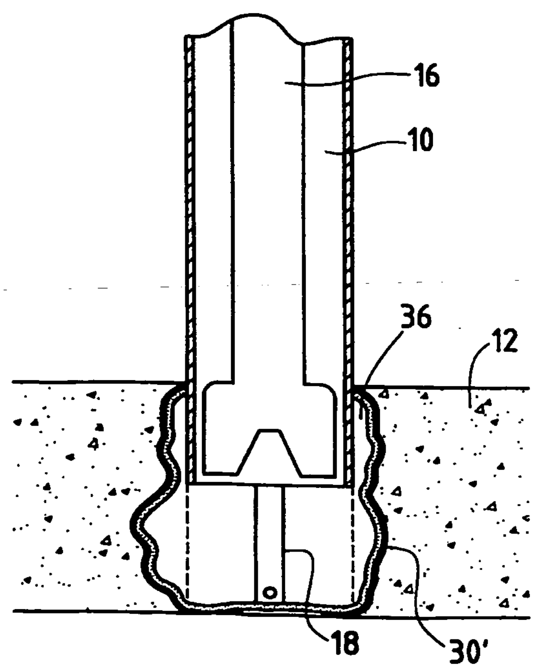
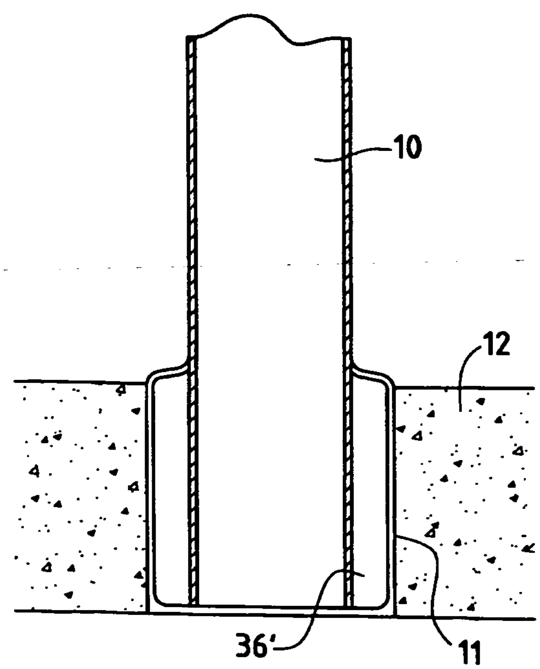


FIG.4



ERNATIONAL SEARCH REPORT

Int ional Application No
PCT/EP 02/12719

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B21/00 E21B43/10 E21B43/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 269 375 A (SCHROEDER JR DONALD E) 14 December 1993 (1993-12-14) abstract	13-15,20
Y		1-3, 5-10, 16-19,21

Y	US 2 922 478 A (MALY JOE W) 26 January 1960 (1960-01-26) the whole document	1-3, 5-10, 16-19,21

P,A	WO 02 01042 A (SHELL CANADA LTD ;LOHBECK WILHELMUS CHRISTIANUS (NL); SHELL INT RE) 3 January 2002 (2002-01-03) page 2, line 29 - line 34	1-21

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 January 2003	20/01/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Garrido Garcia, M

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 02/12719

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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